Before the
Federal Communications Commission
Washington, DC 20554

In the Matter of	)	
	)	
Mitigation of Orbital Debris in the New Space Age	)	IB Docket No. 18-313
	)	

COMMENTS OF THE COMMERCIAL SMALLSAT SPECTRUM MANAGEMENT ASSOCIATION

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I. SUMMARY AND INTRODUCTION

The Commercial Smallsat Spectrum Management Association ("CSSMA") respectfully submits these comments in response to the Notice of Proposed Rulemaking issued by the Federal Communications Commission ("Commission" or "FCC") in the above captioned proceeding.[1]

CSSMA's membership includes many of the leading operators, ground station service providers, manufacturing and component providers, and other service providers in the small satellite ("smallsat") industry.[2] CSSMA seeks to create the conditions for a coordinated, transparent, and expedited spectrum coordination process among commercial smallsat spectrum users, government users, and other satellite and terrestrial users and to advocate and represent the members' views on spectrum management and other policy matters that affect the smallsat community.

Smallsats' short design lifetime, along with their use of miniaturized technology, allow for "regular technology refresh to expand capabilities and improve service quality" for remote

[1] *See Mitigation of Orbital Debris in the New Space Age*, Notice of Proposed Rulemaking and Order on Reconsideration, IB Docket No. 18-313, FCC 18-159 (rel. Nov. 19, 2018) ("*NPRM*").
[2] CSSMA has forty-three (43) members. *See CSSMA*, cssma.space (last viewed Apr. 1, 2019).

sensing, military and intelligence, communications, and scientific operations.[3] Government, educational, and commercial sectors are all taking advantage of the heightened interest in smallsats.[4] Over 1,300 smallsats were launched between 2012-2018.[5] In fact, over 70% of smallsats launched 2012-2018 were cubesats.[6] This trend is not a temporary one. Northern Sky Research forecasts the "market to yield $37 billion in cumulative revenues from smallsat manufacturing and launch services by 2027, with 6,500 smallsats set to launch during this time."[7]

To ensure a safe orbital environment while not hindering a quickly growing smallsat industry in the United States, CSSMA (i) urges the Commission to integrate relevant technical expertise of other U.S. Federal agencies or government bodies and avoid creating piecemeal and potentially duplicative regulation and (ii) emphasizes that any new orbital debris guidelines should focus on improved tracking of spacecraft and derelict debris, sharing of ephemeris data, consideration of collision risk probability <u>and</u> consequence, and post-mission disposal efficacy.

Finally, solving the orbital debris problem will require more than regulating the influx of new constellations. CSSMA notes that the removal of *existing debris* in orbit is critical to maintaining a safe and sustainable orbital environment.

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[3] Caleb Henry, *NSR: Smallsat Market to More than Double Over Next Decade*, Via Satellite (Oct. 24, 2016), https://www.satellitetoday.com/business/2016/10/24/nsr-smallsat-market-double-next-decade/.
[4] *See Smallsats by the Numbers 2019*, Bryce Space and Technology at 4, https://brycetech.com/downloads/Bryce_Smallsats_2019.pdf (last viewed Mar. 22, 2019).
[5] *See id.* (including smallsats on both successful and failed launch attempts).
[6] *See id.*
[7] *Small Satellites Flying High with $37 Billion Market and 6,500 Satellites to Launch by 2027*, Northern Sky Research (Nov. 28, 2018), https://www.globenewswire.com/news-release/2018/11/28/1657948/0/en/Small-Satellites-Flying-High-with-37-Billion-Market-and-6-500-Satellites-to-Launch-by-2027.html.

II. THE COMMISSION SHOULD RELY ON OTHER U.S. GOVERNMENT BODIES' ORBITAL DEBRIS TECHNICAL EXPERTISE AND AVOID CREATING POTENTIALLY PIECEMEAL AND UNNECESSARY DUPLICATION OF ORBITAL DEBRIS GUIDELINES. (*NPRM* ¶¶ 14-17)

The Commission notes that there are other Federal agency stakeholders overseeing orbital debris mitigation. CSSMA does not take a position on the jurisdictional questions or the Commission's statutory authority to promulgate orbital debris rules. Instead, CSSMA encourages the Commission to account for the following considerations if it makes any changes to the current orbital debris mitigation rules.

i) *Integrate relevant technical expertise of other U.S. Federal agencies or government bodies and avoid creating piecemeal and potentially duplicative regulation.* As the Commission notes many times throughout the *NPRM*, National Aeronautics and Space Administration ("NASA") already has developed relevant orbital debris standards.[8] In Space Policy Directive-3, the White House directs the Department of Commerce and NASA to take on various activities related to space situational awareness and space traffic management.[9] Finally, the National Oceanic and Atmospheric Administration ("NOAA") Commercial Remote Sensing Regulatory Affairs office requires applicants to provide spacecraft disposal and orbital debris mitigation plans with their applications.[10] Various Federal entities already have or will have relevant standards or requirements, and the Commission should avoid duplicating and creating a potential piecemeal set of requirements.[11]

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[8] *See Process for Limiting Orbital Debris*, NASA Standard 8719.14, (May 25, 2012) ("NASA-STD").
[9] *See* Space Policy Directive-3, National Space Traffic Management Policy, Presidential Memorandum (June 18, 2018), https://www.whitehouse.gov/presidential-actions/space-policy-directive-3-national-space-traffic-managementpolicy/.
[10] *See* 15 CFR Part 960.
[11] *See* Space Frontier Act of 2019, S.919, 116th Cong. § 305 (2019) (noting that "[i]t is the policy of the United States to have consistent standards across Federal agencies).

ii) *Own the regulation of orbital debris guidelines if the Commission ends up taking on full jurisdiction.* The Commission should look to increase its internal expertise on orbital debris matters and also balance both government/commercial interests when creating and enforcing new guidelines.

III. "ONE-SIZE-FITS-ALL" RULES SHOULD BE AVOIDED, AND PERFORMANCE-BASED RULES SHOULD GOVERN.

Performance-based requirements should provide flexibility, scalability, and adaptability for operators.

A. Rules application to non-Earth orbits

An increasing number of non-geostationary satellite orbit ("NGSO") spacecraft will be licensed to operate in non-Earth orbits. Non-Earth-orbiting spacecraft, making transits to other planetary bodies or deep space destinations, should be exempt from all Earth-centric orbital debris rules. New rules should be developed around other celestial bodies as needed.

However, any potential Earth-orbiting rules should apply to these spacecraft when passing through Earth orbit after launch and on the way to deeper space.

B. Control of debris released during normal operations and multi-satellite deployments (*NPRM* ¶¶ 18-21, 40-41)

The Commission proposes various disclosure requirements when generating operational debris when using deployment devices.

Deployment devices enable stable, timed deployments, and if they meet collision avoidance and orbital debris guidelines, they should continue to be utilized. The deployment devices (such as SHERPA) enable small-to-medium sized spacecraft to be aggregated onto a single mission, making launch efficient and affordable. Deployment devices and spacecraft should each be individually responsible for obtaining their own licensing. It is industry practice already that a deployment device provider (like SHERPA) is responsible for showing probability of collision up to two (2) orbits following the last deployment.[12] In the case of Spaceflight's SSO-A mission,[13] customers were prevented from maneuvering for the about first ~12 hours after launch; by that time, the spacecraft have dispersed enough that there is very little chance of a recontact event.

The Commission also seeks comment on its proposal for applicants to include information related to the deployment of multiple satellites on a single launch and whether the strategies employed to mitigate collisions during the post-launch phase – and between those deployed satellites that end up sharing similar orbits – should be assessed in conjunction with the Commission's standard collision risk analysis. CSSMA believes that this requirement is unnecessary, as operators, launch aggregators, and launch providers will always have a strong, independent commercial incentive to mitigate this risk themselves and to ensure that post-launch operations are completed successfully. The submission of this information and its subsequent assessment would therefore always be completed in redundancy and would fail to add new value to an applicant's mitigation analysis.

C. Minimizing debris generated by release of persistent liquids (*NPRM* ¶¶ 22-23)

CSSMA recommends not taking premature action regarding the release of persistent liquids without evidence showing such liquids could cause an orbital debris risk. Of particular concern is the possibility of the FCC regulating alternative propellants without clear evidence basis that such propellants if released as designed and as part of normal operations will in fact persist in the orbital environment as droplets. CSSMA opposes any regulation of non-traditional propellants and propellant systems that simply identifies the type of liquid and does not also take

[12] *See* Stamp Grant, Spaceflight, Inc., SAT-STA-20180523-00042 (granted Oct. 12, 2018); *Updated SSO-A Long-Term Recontact Probability*, Spaceflight, Inc., SAT-STA-20180523-00042 (filed Aug. 8, 2018).
[13] *See Introducing SSO-A: The Smallsat Express*, Spaceflight, http://spaceflight.com/sso-a/ (last viewed Apr. 2, 2019).

into account the design and engineering specifics of the particular propulsion system, including the temperature at which such liquid is heated and the amount of material (in gaseous or other form) ejected from the propulsion system. These novel and highly technical risks highlight why it is premature to implement such regulation.

D. Safe flight profiles (*NPRM* ¶¶ 24-25)

The FCC's inquiry into safe flight profiles raises the fundamental issue regarding how existing and future operators in low-Earth orbit ("LEO") should share the burden of collision avoidance. For example, if future operators need to ensure that their planned satellite operations bear the full burden of collision avoidance to existing satellite operators, then the FCC must be mindful of the preemptive impact of the deployment of a "large" constellation (in terms of total number of satellites, aggregate mass, and/or total cross-sectional area) in any particular orbit or region in space. Indeed, these issues have already arisen in a handful of license application proceedings.[14] As LEO becomes increasingly more crowded, it will be even more critical for operators to know the "rules of the road" for safe and efficient operations and have certainty regarding their regulatory obligations for collision avoidance.

Rules, such as requiring all satellites to have propulsive capability, should not be based on simplistic and unsupported positions. As CSSMA has explained in other proceedings, smallsats without propulsion (even in large constellations) can pose a considerably smaller collision threat due to their smaller mass and cross-sectional area and minimal stored energy (resulting from the lack of fuel/propellant or pressurized systems).[15] Moreover, the Commission

[14] *See* Application of Space Exploration Holdings for Modification of Authorization for the SpaceX NGSO Satellite System, File No. SAT-MOD-20181108-0008 (filed Nov. 8, 2018) ("SpaceX Mod"); Application of Planet Labs Inc., File No. SAT-MOD-20150802-00053 (filed Aug. 2, 2015); Application of Spire Global, Inc., File No. SAT-LOA-20151123-00078 (filed Nov. 23, 2015).

[15] *See also infra* Section III(D)(1), (5) (explaining that propulsive capability does not necessarily mean collision avoidance capability).

should support a commercial space policy that facilitates opportunities for space actors having varying business plans and technologies and not attempt to pick winners and losers.[16]

Unfortunately, there is no simple answer to the issue of how existing and future operators in LEO should share the burden of collision avoidance. CSSMA believes that a starting point for discussions should be a joint, objective industry-led technical study regarding the limits of the physical capacity for the shared use of LEO. Without a scientific measure, it would be difficult to justify any policy decisions regarding the fair use of LEO and the proper allocation of the burden for collision avoidance. CSSMA will continue to engage with other commercial and government entities in the wider conversation.

1. Collision risk probability and consequence (*NPRM* ¶¶ 26-28)

Broadly, CSSMA supports the proposal to codify the NASA-STD for single-spacecraft collision risk of 0.001 and 0.01 for "large" and "small" objects respectively. CSSMA believes the existing definition of large and small objects, despite being somewhat arbitrary, remains suitable for these purposes.

The Commission seeks comment on whether such limits should also be applied on an aggregate, system-wide basis and whether the same metrics should be used in those cases. The Commission goes further and asks whether these limits should be made stricter for what are termed "large constellations."

CSSMA supports the application of limits on an aggregate basis and also the setting of such limits as a function of a given system's properties. However, CSSMA questions both the

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[16] *See*, *e.g.*, *Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in A Reasonable & Timely Fashion, & Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996*, Report, 14 FCC Rcd 2398 ¶ 5 (1999) ("Our role is not to pick winners and losers, or to select the best technology to meet consumer demand."); *Creation of Low Power Radio Service, Report and Order*, 15 FCC Rcd 2205 (2000) (Statement of Chairman William Kennard) ("[I]t is not the business of the FCC to pick winners and losers.").

fairness and effectiveness of applying stricter limits to systems arbitrarily deemed to be "large." CSSMA points out that size alone does not adequately indicate the risk of a given system.[17] Collision risk calculations involve significantly more than just number of spacecraft in orbit, and any application of more stringent limits to certain systems should also take these factors into account. Specifically, the application of stricter limits should be based on a more granular calculation of risk; rather than targeting "large" constellations, the Commission should instead seek to address "impactful" ones. Specifically, a constellation's "impact" or "consequence" should be calculated as a function of several critical contributing factors, including number of satellites, expected failure rate (*i.e.*, loss-of-control), cross-sectional area, mass, orbital altitude and spatial density, and orbital decay time. In this way, limitations are better aligned with real operator mission risk. Further, the inclusion of mass in this calculation also allows for the *consequence* of a collision to be taken into account.[18] These effects however still do not account for second-order collisions that might occur as a result of the debris generated by an initial impact. Additionally, if an applicant complies with the above-mentioned thresholds, the Commission should consider its collision risk analysis to be sufficiently informative and not require any additional justification for operations above 650 km.

CSSMA opposes the Commission's existing practice of assuming a collision risk of zero whenever a system is capable of active maneuvering. Critically, this assumption does not take

[17] For example, when surface area and mass are also considered, a system of 50 large satellites could reasonably have the same impact on the debris environment as a system of 200 smaller satellites.

[18] This effect has previously not been accounted for in Commission assessments of risk. For further reference on how mass affects the debris environment, see the following document. *See* Darren Garber, et al., *Responsible Behavior for Constellations and Clusters*, Space Traffic Management Conference (Jan. 16, 2018), https://commons.erau.edu/cgi/viewcontent.cgi?referer=https://www.google.com/&httpsredir=1&article=1175&context=stm . The study identifies several large clusters of derelict, non-functional debris that currently exist in LEO. One cluster – termed "C850" – consists of 16 rocket bodies and 16 payloads that share a similar orbit at 850 km and 72° inclination. The study found that a first-order collision between two of these clustered objects would create, on average, approximately 16,000 pieces of trackable (*i.e.*, > 10 cm) debris. In contrast, a similar collision between two 3U cubesats would create, on average, only about 14 pieces of trackable debris.

into account the operational risks associated with the execution of these maneuvers nor does it account for the *degree* of maneuverability of a given spacecraft. It assumes that such maneuvering systems are both 100% reliable and 100% accurate. Neither of these are true as active propulsion systems are subject to maneuver-related errors stemming from factors such as "ignition" reliability, available delta-v, and thrust-to-mass ratio. CSSMA urges the Commission to reconsider the use of this assumption.

CSSMA opposes the Commission's suggestion that operators should account for planned (versus operational) constellations in their statements regarding collision risk. Such an analysis would come at significant additional expense to operators as no central repository exists that is capable of readily providing this information. Unlike operational systems, planned systems are also subject to sudden modification, which could rapidly render a submitted analysis meaningless. Further, operators cannot account for systems that are not publicly disclosed, including those planned by foreign or domestic agencies for national security or by unknown private companies.

2. Orbit selection (*NPRM* ¶¶ 29-35)

The CSSMA supports the proposal that operators provide information about their strategy to avoid collisions with and minimize disruption to the International Space Station or any inhabitable spacecraft as operators already present this information in their application. Operators can describe their collision avoidance maneuver capabilities using propulsion, differential drag, or other method as well as explain their engagement with Combined Space Operations Center ("CSPoC") or other space traffic management entities.

Regarding orbit selection, CSSMA agrees with Aerospace Corporation's ("Aerospace's") recommendation[19] that specifying a minimum probability of success for post-mission disposal should be the overarching goal. If an applicant meets the applicable single/aggregate collision risk and post-mission disposal rate thresholds, then no additional rationale needs to be given for its orbit selection. In addition, propulsion should not be mandated for station-keeping or collision avoidance maneuvers. Instead, the new guideline might be stated in terms of reducing the probability of collision to less than some threshold within a specified warning period.[20] Operators are then allowed flexibility between conventional designs and innovations that meet the collision risk and disposal rate thresholds.

Finally, while orbital separation and/or orbital variance limits seem to be a good principle, it is however not practicable. The majority of smallsat operators are secondary payload launch customers and do not have control over their insertion orbits. There are often inter-constellation overlaps within a singular deployment. Propulsion-less satellites (and those with propulsion but not used for de-orbit) drift downward over time through all altitudes below them, so any orbital separation or variance limits cannot be maintained over the lifetime of the satellite. Imposing such limits would prejudice cubesat and other smallsat operators from fair and reasonable access to critical low-Earth orbit resources. Ultimately, the majority of satellites and objects will not be in tightly maintained orbits, and other methods of space traffic management and collision avoidance strategies will be required anyway. The CSSMA instead proposes that any rules simply specify collision risk and post-mission disposal rate thresholds to be met.

[19] *See* Comments of the Aerospace Corporation, IB Docket No. 18-313, at 10 (filed Mar 7, 2019) ("Aerospace Comments").
[20] *See id.*

3. Tracking (*NPRM* ¶¶ 36-38)

CSSMA supports the proposal to require a statement indicating sufficient trackability of proposed satellites. However, CSSMA urges the Commission not to implement a requirement for a *specific type* of tracking technology, such as passive radar reflectors or satellite navigation system transponders. Rather, the Commission should permit operators flexibility to choose appropriate solutions based on the marketplace and technology. Indeed, ground-based space situational awareness capabilities may, in the future, improve to such a degree so as to make on-orbit technologies unnecessary, and mandating any such use would be unnecessary. Therefore, CSSMA proposes that the Commission require applicants to simply certify that they can be tracked reliably by widely available tracking technology.

The correct identification of tracked objects is materially useful for coordination affairs. CSSMA also notes that operators typically already voluntarily share their NORAD Catalog Number or International Designator (together "designators"), which are standard in the industry, with the 18th Space Control Squadron ("SCS").

4. Data sharing and maintaining ephemeris data (*NPRM* ¶¶ 36-38, 72-73)

CSSMA notes that it is already industry practice and in the business interest for operators to make available tracking data, if feasible, to external parties of interest during conjunction avoidance events. Its operators typically share tracking/ephemeris data and contact information with, at minimum, the 18th SCS but also with all other operators that may pose an immediate collision risk as determined by the issuance of an applicable conjunction notice or other commercial entitles, such as the Space Data Association, which aggregate such information. Such sharing protects important business assets and future viability of space.

Outside of conjunction events, some CSSMA operators already maintain a publicly-available central repository, containing tracking information, for their satellites.[21] It should be encouraged but not required to maintain such a repository at this time.

5. Maneuverability (*NPRM* ¶ 39)

In the *NPRM*, the Commission proposes that applicants describe the extent of any maneuverability of their space systems both during the satellites' operational lifetimes and during the remainder of their time in space prior to disposal. The Commission seeks comment on whether this information will, in fact, assist them in its public interest determination, particularly regarding any burden that other operators would have to bear to avoid collisions and false conjunction warnings.

First, CSSMA notes that its members operate space systems that fall into three categories: 1) having propulsion and are capable of conjunction avoidance maneuvers; 2) having capable attitude control maneuvers and are capable of performing collision avoidance maneuvers using differential drag techniques in response to conjunction notices; and 3) having no sophisticated attitude control systems, which cannot respond to conjunction notices in a timely manner.

Notwithstanding the range of performance capabilities of CSSMA member systems, CSSMA collectively agrees with the Commission's findings that collecting high quality information regarding the abilities of all applicants' space systems is very much in the public interest and will facilitate the minimization of collisions in space, where and when they can be avoided.

[21] *See*, *e.g.*, *Planet Labs Public Orbital Ephemerides*, Planet, http://ephemerides.planet-labs.com/ (last viewed Apr. 3, 2019); *Open TLE Service*, Spire, tle.spire.com (last viewed Apr. 3, 2019). To obtain the ephemeris data for any particular satellite, type in the Spire satellite's NORAD ID after "tle.spire.com/" in the URL bar.

CSSMA further supports the Commission's proposal not to require that all satellites have propulsion capability. Depending on the design and goals of the propulsion system it might not be suitable for collision avoidance maneuvers. It might only be meant for slow (*i.e.*, low specific impulse) orbit raising/lowering or station-keeping along a plane for example.

In terms of maneuverability, CSSMA notes that a majority of smallsat systems can control the attitude of their spacecraft AND virtually all of these spacecraft have variable area-to-mass characteristics depending on their instant attitude with respect to the velocity vector of their orbit. These two conditions, as just described, are necessary and sufficient to allow such systems to execute various forms of differential drag maneuvers. As CSSMA notes further below, considerable work has been done, particularly by CSSMA members Astro Digital, Planet, and Spire, on using differential drag as an operational means of constellation orbit maintenance *as well as conjunction avoidance*.

However, some small space systems are still not capable of any meaningful form of collision avoidance maneuverability. As these systems are typically single spacecraft and typically on the low end of the size/mass/volume scale (even among small space systems), CSSMA believe that these systems do not constitute a large debris threat. This statement is particularly true, if they are confined to either very low LEO orbits or, alternatively, highly eccentric orbits with very low perigee values (*e.g.*, Geostationary Transfer Orbit-type orbits).

In this *NPRM*, the Commission has specifically requested comment regarding the effectiveness and suitability of differential drag maneuverability as well as other particular maneuvering technologies. CSSMA notes the Commission cites differential drag as an emerging area of technology. One of the original small space system Mobile-Satellite Service operators, ORBCOMM, used differential drag very successfully to adjust its first generation constellation inter-satellite satellite spacing within each orbital plane.[22] It was demonstrated on one of the early ORBCOMM OG-1 satellites in the mid-1990s.[23] However, while differential drag as an orbit adjustment method is not truly new or novel, perhaps its use as a primary method of conjunction avoidance could still be considered as "emerging." CSSMA supports the notion of better defining the capabilities of differential drag and any other viable maneuvering technology through practical use and further experimentation using in-orbit systems, and it encourages the open dissemination of research and in-orbit results pertaining to these topics. CSSMA again notes that three CSSMA organizations (Astro Digital, Planet, and Spire) have committed significant resources to routine operations using the differential drag method. There may be other operators, including ORBCOMM, currently doing likewise of which CSSMA is not aware. In response to the Commission's questions on this topic, CSSMA cites several documents that summarize its members experience with differential drag.[24]

In the *NPRM*, the Commission seeks information regarding any specific applicant disclosure requirements with respect to this or other types of emerging maneuvering technology. CSSMA believes that the CSpOC conjunction warning system, as it is currently operating, has been an essential, useful, and particularly helpful augmentation to their overall role in space situational awareness. In that regard, CSSMA believes that this system could be further

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[22] *See* Scott Hull, et al., *Differential Drag Demonstration: A Post-Mission Experiment with the EO-1 Spacecraft*, IAA-ICSSA-17-0X-XX §§ 2, 7, https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/2017 0010724.pdf (last visited Apr. 1, 2019).

[23] *See id.*

[24] The following documents discuss the viability of differential drag for maneuverability purposes. *See, e.g.*, Joseph Gangestad, et al., *Flight Results for AeroCube-6*, Aerospace Corporation (Apr. 22-24, 2015); Cyrus Foster, et al., *Orbit Determination and Differential-Drag Control of Planet Labs CubeSat Constellations*, AAS 15-524 (Sept. 2015), https://arxiv.org/pdf/1509.03270.pdf; Application of Astro Digital U.S. Inc., IBFS File No. SAT-LOA-20170508-00071, Attachment F, (May 8, 2017) ("AD DD Exhibit").

enhanced to facilitate even more *rapid operator action.* CSSMA believes the following enhancements could be made to assist the data sharing briefly discussed in Section III(D)(4).

1) The conjunction warning could identify to an operator that the other object associated with a conjunction is believed to be an *uncontrolled space object*. (CSSMA notes that more than 94% of all space debris that could be involved in a conjunction are currently in this category.)[25]

2) The conjunction warning could include a data field describing the other operator's object's *maneuverability type*.

3) The conjunction warning could include probability of collision figures. This field is often left blank currently.

4) The conjunction warning could include data fields containing the two objects' responsible points of contacts (with contact details) when applicable.

CSSMA believes that rapid access to this type of information would maximize the effectiveness of any action that might be taken by an operator during a rapid response to a CSpOC-issued conjunction event.

6. Design reliability (*NPRM* ¶¶ 42-43)

The CSSMA believes that design and fabrication reliability metrics for large- and high-altitude constellations should be a goal but should not be a mandatory requirement. Though additional restrictions on those larger and more persistent constellations may be prudent responses to the higher risk of creating orbital debris they pose, a disposal reliability requirement would be a more efficient and less cost prohibitive way of mitigating that risk.

[25] *See* AD DD Exhibit at 3 (noting that there are 21,000 objects in space and that slightly less than 1100 of those are active satellites and that the rest are uncontrolled objects).

E. Post-mission disposal (*NPRM* ¶¶ 44-45)

1. Probability of success of disposal method (*NPRM* ¶¶ 46-57)

The Commission considers incorporating a disposal reliability metric of 0.90 for spacecraft operating across the entire LEO region and other disposal-related requirements for the 650-2000 km LEO region. Most if not all of CSSMA's LEO operators operate below 650 km, so CSSMA only comments on a potential disposable reliability metric rule applicable to operations below 650 km.

CSSMA supports a post-mission disposal success rate of 1.0, applied on an aggregate basis, below the 650 km orbital altitude. The strong atmospheric drag present below this altitude will ensure that the majority of satellites deployed here will deorbit within 25 years as the Commission states.[26]

2. Post-mission lifetime (*NPRM* ¶¶ 58-59)

CSSMA is opposed to the Commission shortening the existing post-mission lifetime rule to less than 25 years. It is important that the Commission consider the impact that changes to existing orbital rules on post-mission lifetime may have on current authorized satellite operators and operators that have applied for authorization. CSSMA urges the FCC to consider that any changes to post-mission lifetime could result in companies going out of business and seriously harm U.S. innovation and competitiveness in the smallsat industry unless the FCC grandfathers existing or pending systems to provide them additional time to evolve their technology and business plans. It is particularly relevant for NGSO operators operating under 650 km within the context of existing post-mission orbit lifetime. If the FCC rules that post-mission lifetimes must be less than 25 years, NGSO smallsat operators that have built their businesses, including the

[26] *See NPRM* ¶ 31. Depending on the mass-to-area ratio, some satellites deployed in the range 600-650 km may exceed 25 years to de-orbit but generally will still de-orbit within a few decades.

technology of their satellites and the financing to support commercial business operations, under the 25-year post-mission orbit lifetime regulatory standard may potentially no longer be able to continue business activities.

CSSMA supports the FCC and other U.S. government agencies incentivizing operators to accelerate post-mission de-orbit and end-of-life activities so long as such incentivization is truly voluntary and not required by regulation. For example, the FCC could offer discounts or waivers of regulatory licensing fees to operators that voluntarily accelerate post-mission de-orbit and end-of-life activities.

3. Casualty risk assessment (*NPRM* ¶¶ 60-62)

Commission proposes two specific informational requirements for satellites with a planned post-mission disposal of uncontrolled atmospheric re-entry.

CSSMA agrees that the human casualty risk assessment should include all objects that would have an impacting kinetic energy in excess of 15 joules, which is consistent with the NASA-STD.[27]

CSSMA notes that a statement indicating the actual calculated human casualty risk, as well as the input assumptions used in modelling re-entry, should be required *only if* the risk is greater than the NASA-STD for human casualty upon re-entry of 1:10,000.[28] While smallsats have much smaller mass, re-entry risk is not driven solely by mass, but it is also driven by materials used for the satellite bus and components. Nothing is ever zero, although NASA Debris Assessment Software and other programs will eventually round down to zero at the fifth or sixth decimal place.

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[27] *See* NASA-STD Requirement 4.7.2.
[28] *See id.*

CSSMA agrees with two of Aerospace's additional suggestions regarding human casualty risk rules. Specifically, CSSMA supports the encouraging of disposal techniques that minimize time in orbit with a preference for highly reliable direct disposal into a safe area to minimize the risk to people on the ground and in aircraft.[29] CSSMA also agrees with Aerospace's recommendation of "changing 'probability of human casualty' to 'risk of human casualty' throughout [any] proposed regulation. Risk of human casualty, also known as casualty expectation, has units of 'people' and has an upper threshold of total people exposed to becoming a casualty."[30]

F. Operational rules

1. Orbit raising/lowering (*NPRM* ¶¶ 70-71)

Commission seeks comment on whether an authorization for NGSO satellites include authority for telemetry, tracking, and command functions to raise the satellite to its normal orbit following launch. It also proposes to require such telemetry, tracking, and command operations to be coordinated between satellite operators as necessary to avoid interference events, rather than require the operations to be performed on a non-interference basis, and inquires whether such a requirement should apply to GSOs in addition to NGSOs.

CSSMA only comments on the applicability of these rules to systems operating in Earth Exploration-Satellite Service, Meteorological-Satellite Service, and Space Operations Service frequency bands as CSSMA members primarily only operate in these frequency bands. In these bands, the operations are on a non-exclusive basis as these systems only transmit/receive when a satellite is in line of sight of an earth station, allowing for operators to share the bands for both operational and telemetry, tracking, and control ("TT&C") activities. Therefore, CSSMA does

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[29] *See* Aerospace Comments at 13.
[30] *See id.* at 17.

not believe regulated radiofrequency ("RF") coordination requirements are necessary in these bands.

2. Telemetry, tracking, and command encryption (*NPRM* ¶¶ 74-75)

CSSMA supports the protection of command links as most if not all operators do encrypt already (incentivized by business and asset protection interests), but it cautions against mandating a specific requirement and methodology on all communication channels.

Regarding satellites with propulsion, it has been proposed that such satellites may pose an acute risk to other satellites if a malevolent actor takes control of the unsecured satellite. However, such an action requires exceptional planning, execution, sophisticated guidance equipment not found on most commercial satellites and ultimately is a very unrealistic scenario.[31] Furthermore, the risk depends, in part, on the delta-v and thrust available on the satellite taken over by a malevolent actor. Most smallsats have very little delta-v and thrust. Instead, encryption would prevent malevolent actors from learning how a spacecraft works, gathering data from licensed instruments, or using the instruments to cause RF interference.

There are many methods to secure a communication channel with varying levels of sophistication depending on the security needs of the satellite mission and each communication link. Any specific sufficiency requirement is bound to be inappropriate for some channels and may limit the innovation or flexibility of better methods to choose from. One example where encryption may not be appropriate is on a channel control link for the optimization of a data channel, such as the return channel of an Adaptive Coding and Modulation ("ACM")[32] loop or

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[31] *See* Andrew Kurzrok, et al., *Evaluating the Risk Posed by Propulsive Small-satellites with Unencrypted Communications Channels to High-Value Orbital Regimes*, SSC18-XI-05 at 6 (2018), https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=4135&context=smallsat.

[32] For example, the ACM scheme is used in the DVB-S2 transmission protocol. *See Digital Video Broadcasting (DVB); Second generation framing structure, channel coding and modulation systems for Broadcasting, Interactive Services, News Gathering and other broadband satellite applications; Part 1: DVB-S2*, ETSI at Annex D (July 2014).

transmit power control as noted in 47 C.F.R § 25.204. These control loops are very limited in functionality and often autonomous at the earth station where the control and security of an encryption system may be impractical and unnecessary for the link.

For the case of data channels, the operator will choose a level of protection required to protect its business interests, and other Federal regulations already impose data protection requirements where there may be a national security risk from data in the hands of bad actors.[33] The decision of method and sufficiency should be left to the operator, which is already self-incentivized by business and asset protection interests. Except, CSSMA does support imposing cryptographic protection of critical satellite command and control links.

IV. AN INDEMNITY AGREEMENT REQUIREMENT SHOULD NOT BE REQUIRED. (*NPRM* ¶¶ 78-79)

The CSSMA strongly opposes any requirement on space station licensees to indemnify the United States against any costs associated with a claim brought against the United States related to the authorized facilities. The reason for this opposition is that the effect of such a requirement would be contrary to U.S. national interests in promoting innovation and competitiveness and ensuring the United States is the jurisdiction of choice for space activities. The effect would likely include increasing insurance costs, potentially to the point where insurance will not be reasonably affordable for commercial start-ups and operators, and creating an incentive for licensees to go to foreign jurisdictions without such indemnification requirements.

Furthermore, while it is true that the United States is a party to the Convention on International Liability for Damage Caused by Space Objects of 1972 ("Liability Convention")[34]

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[33] *See*, *e.g.*, 15 CFR Part 960.
[34] *See* Convention on International Liability for Damage Caused by Space Objects of 1972.

and is liable as a Party to that treaty in instances in which it is "Launching State," the benefit of imposing such an indemnification requirement is negligible. The benefit of imposing an indemnification requirement on space station licensees would presumably be to limit the possible future fiscal exposure of the U.S. government to a claim under the Liability Convention. However, in practice, this situation does not seem reasonable. For non-catastrophic liability claims, the likelihood of a State-to-State claim is likely low given the political costs and efforts required to assert such a claim under the Liability Convention. For more serious circumstances, including catastrophic loss, such a loss would likely not be insurable, and if a licensee were required to indemnify, it would in fact not be able to pay. So, the United States would still be responsible for and have liability under the Liability Convention. In addition, it should be noted that in some instances, an FCC space station licensee may not in fact have a sufficient legal nexus to the United States to imbue the status of "Launching State" upon the United States.

The existing liability and indemnification regime governing U.S. Department of Transportation-licensed launch vehicles should be taken into account. Under the federal law governing launch licensing, licensees are required to obtain certain levels of insurance,[35] and Congress provides the launch industry certain catastrophic indemnification coverage in the event of an accident. This liability regime protects and fosters the U.S. launch industry. If indemnification is required, a similar liability regime should be considered to protect space station licensees in the event of a catastrophic event.

V. INSURANCE REQUIREMENTS DO NOT NECESSARILY INCENTIVIZE GOOD BEHAVIOR ON ORBIT. (*NPRM* ¶ 80)

The Commission inquires generally on the costs and benefits of insurance as an economic incentive for orbital debris mitigation.

[35] *See* 51 USC § 50914.

Secure World Foundation and the Stimson Center recently partnered to host a roundtable discussion on the relationship between space insurance and incentivizing responsible behavior in space, and "the main takeaway was that given how competitive pricing is within the space insurance market, space insurance companies do not have the flexibility to use pricing as a way in which to encourage responsible behavior."[36] CSSMA agrees.

> Imposition of insurance requirements does not necessarily influence safe spacecraft profiles. Space insurers would like to reduce premiums for better actors, but the pricing challenge prohibits any meaningful action. Those selling insurance have very little pricing power and very little direct interaction with their customers - most of it goes through brokers, who depend heavily on models to determine pricing. There is very little flexibility for space insurance pricing for the insurers.[37]

Moreover, pricing for insurance is not driven by operational experience.[38] Insurance rates are lower now than they were in the 2000s,[39] which is counterintuitive considering China's intentional fragmentation of the Fengyun 1C spacecraft in 2007, the Iridium-Cosmos collision in 2009, and greater proliferation of spacecraft on orbit in the 2010s.[40]

Finally, good behavior on orbit and end goals have not been defined.[41] As a result, it is hard for insurance providers to hold operators to any meaningful standards currently. Instead, the marketplace should be pushing standards development.

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[36] Victoria A. Samson, et al., *Can the Space Insurance Industry Help Incentivize the Responsible Use of Space?*, IAC-18-E3.4.2 at 2 (Oct. 2018), https://swfound.org/media/206275/iac-2018_manuscript_e342.pdf ("*Space Insurance Paper*").
[37] *Id.* at 4.
[38] *See id.*
[39] *See id.* at 3-4.
[40] *See NPRM* ¶¶ 8-9.
[41] *See Space Insurance Paper* at 4 ("What problem are we trying to solve: are we trying to avoid collisions? Stop radio frequency interference? Prevent satellites from having to maneuver and shorten their lifespans? There needs to be a discussion about the end-goal in order to determine the best way to reach it.").

VI. ANY NEW RULES SHOULD APPLY TO EXPERIMENTAL AND AMATEUR SATELLITE OPERATIONS; HOWEVER, WAIVERS IN THE PUBLIC INTEREST SHOULD BE GRANTED. (*NPRM* ¶¶ 82-84)

Any new rules should apply to experimental and amateur satellite operations; however, the Commission can grant waivers on a case-by-case basis if the grant is in the public interest. CSSMA notes that any form of indemnity insurance requirement imposed upon educational institutions, amateur satellite organizations, or other non-profit entities engaged in experimental activities would likely be an unbearable cost to these organizations.

VII. EXCEPT FOR INDEMNITY, INSURANCE, OR SIMILAR REQUIREMENTS, ANY NEW RULES SHOULD ALSO APPLY VIA LICENSE CONDITION TO A MARKET ACCESS GRANT TO NON-U.S. APPLICANTS. (*NPRM* ¶¶ 85-87)

CSSMA agrees that all rules, except for indemnity; insurance; or similar requirements, adopted by this proceeding should be made applicable via license condition to market access requests filed by non-U.S. applicants.

CSSMA also agrees with the Commission's previous assessment that failing to do so would undermine the primary policy objective of mitigating orbital debris. Such a requirement will ensure that the updated regime retains the same universal applicability that it does under the existing framework[42] and that it also does not act to incentivize "forum shopping." CSSMA supports the continuation of the Commission's existing practice to assess the effective oversight of foreign licensing authorities on a case-by-case basis and to require information pertaining to the inclusion of applicants' systems in the United Nations Register of Objects Launched into Outer Space.

However, if any indemnity, insurance, or similar requirements are adopted by this rulemaking, despite the opposition raised in Sections IV and V of these comments, CSSMA

[42] *See* 47 CFR § 25.137(b) (requiring the provision of legal and technical information of the kind that would be required for a license application filed under 47 CFR § 25.114).

suggests that foreign operators be exempt from these conditions. Such rules would not only harm non-U.S. licensees for the reasons discussed previously but also because foreign operators can be expected to have already paid similar, comparable expenses to their own respective foreign licensing authorities. Many CSSMA members are small companies based outside of the United States, and a duplicate expense of this type, in addition to the bond requirements under 47 CFR § 25.165, could act to economically prohibit the entry of these operators into the U.S. market. Thus, the application of such requirements would act to disincentivize market access requests in general, precluding the United States from accessing the services offered by such licensees and, therefore, stifling innovation and acting against the public interest.

CSSMA opposes the full application of the adopted rules to non-U.S. licensees, such as those with U.S.-based activities exclusively for TT&C. CSSMA believes it would be excessive to require from these applicants the same kinds of detailed collision- or casualty-risk analyses that are required for systems with a substantial U.S. commercial presence. In lieu, the Commission should continue to require a statement demonstrating compliance with the foreign licensing administration's own orbital debris rules in line with current practice.[43] CSSMA believes this strikes a fair balance between licensure accessibility and cost and would not materially undermine the primary policy objectives of the proposed rulemaking.[44]

VIII. EXISTING LICENSEES AND PENDING APPLICANTS SHOULD BE GRANDFATHERED UNDER OLD ORBITAL DEBRIS RULES.

For any new rules the FCC promulgates, CSSMA strongly recommends the grandfathering of pending license applications (as of the date of adoption of any new rules) and existing licensees so that the new rules do not retroactively apply. Furthermore, CSSMA urges

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[43] *See* 47 CFR § 25.114(d)(14)(v) (requiring that applicants show that their system's orbital debris mitigation plans are subject to direct and effective regulatory oversight by their foreign national licensing authority).
[44] *See NPRM* ¶ 86.

the FCC to take into account that any changes to existing rules must be phased in over a period of several years so that U.S. industry has time to evolve its technology and business plans. Failure to provide for such a runway could result in companies going out of business and seriously harm U.S. innovation and competitiveness in the smallsat industry.

IX. CONCLUSION

CSSMA applauds the Commission's efforts to create a safe and sustainable orbital environment and looks forward to assisting the Commission and other relevant Federal agencies and organizations contemplate new orbital debris mitigation guidelines.

CSSMA urges the Commission to integrate relevant technical expertise of other U.S. Federal agencies or government bodies and avoid creating piecemeal and potentially duplicative regulation. If the FCC is to maintain responsibility, CSSMA emphasizes that any new orbital debris guidelines should focus on improved tracking of spacecraft and derelict debris, mandatory sharing of ephemeris data, consideration of collision risk probability <u>and</u> consequence, and post-mission disposal efficacy.

Respectfully submitted,

CSSMA

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